RUSS COLLEGE of Engineering and Technology

Distributed Energy Project
Project PDP 42

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Objectives

Program Objectives

- Develop technology to aid in creation of a viable “distributed energy” system
  - Provides electricity from stationary solid oxide fuel cells
  - Provide heat from the fuel cells
  - Provide useable hydrogen from the synthesis gas
- Integrate CHP into distributed H_2 production

Overview

Timeline

- Project start 9/1/2005
- Project end date 10/1/2008
- Percent complete 50%

Budget

- Total project funding
  - DOE share $1,091,000
  - Contractor share $ 343,000
- Funding received in FY06: $0
- Funding for FY07 $0

Barriers

- DOE Technical Barriers for Distributed Generation
  - Develop CHP fuel cell systems
  - Verify integrated stationary fuel cell systems
  - Mitigate technical barriers to stationary fuel cells
- DOE Technical Targets for 2010
  - 40,000 hours durability
  - $1000/kWe

Partners

- University of Cincinnati
- State of Ohio's Air Quality Development Authority
- University of North Dakota
- CTP Hydrogen
- U.S. Department of Energy

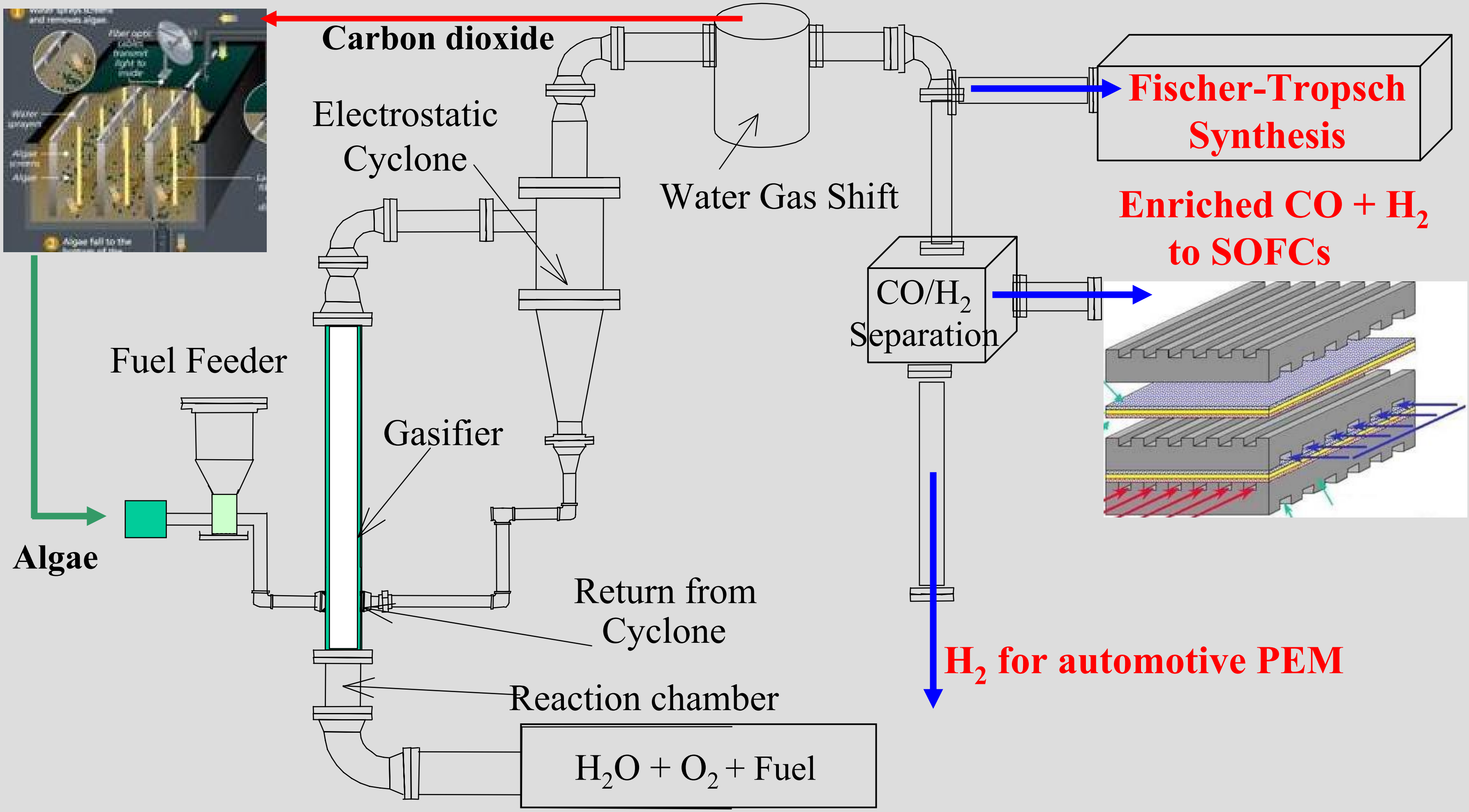
Interactions and Collaborations

Academic and Industrial Partnerships

- University of Cincinnati
- State of Ohio’s Air Quality Development Authority
- University of North Dakota
- CTP Hydrogen
- U.S. Department of Energy

Integrated Energy Vision

Combined Heat, Power, Fuel, H_2 and Carbon Recycling



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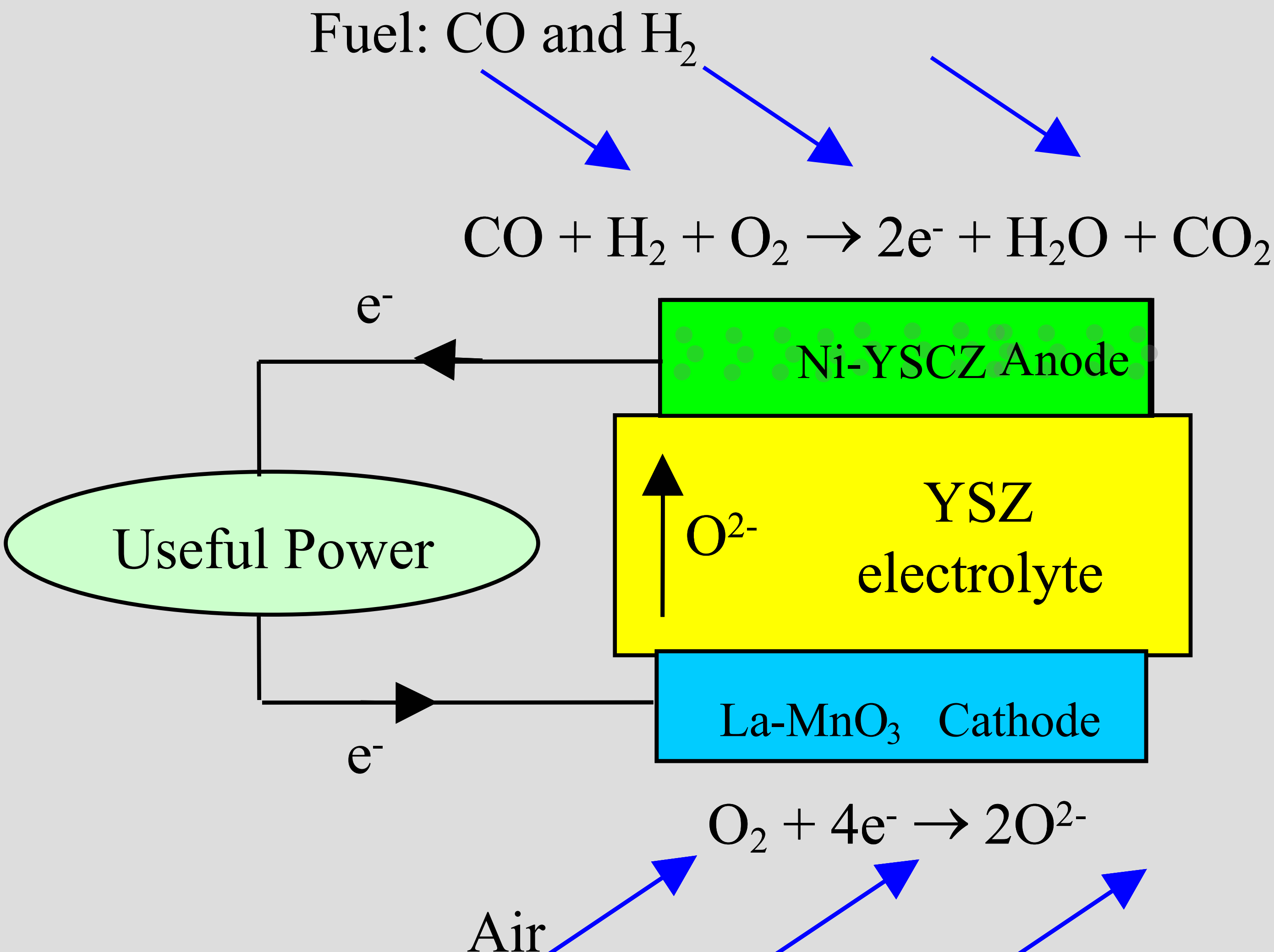
Electrochemical Energy Conversion

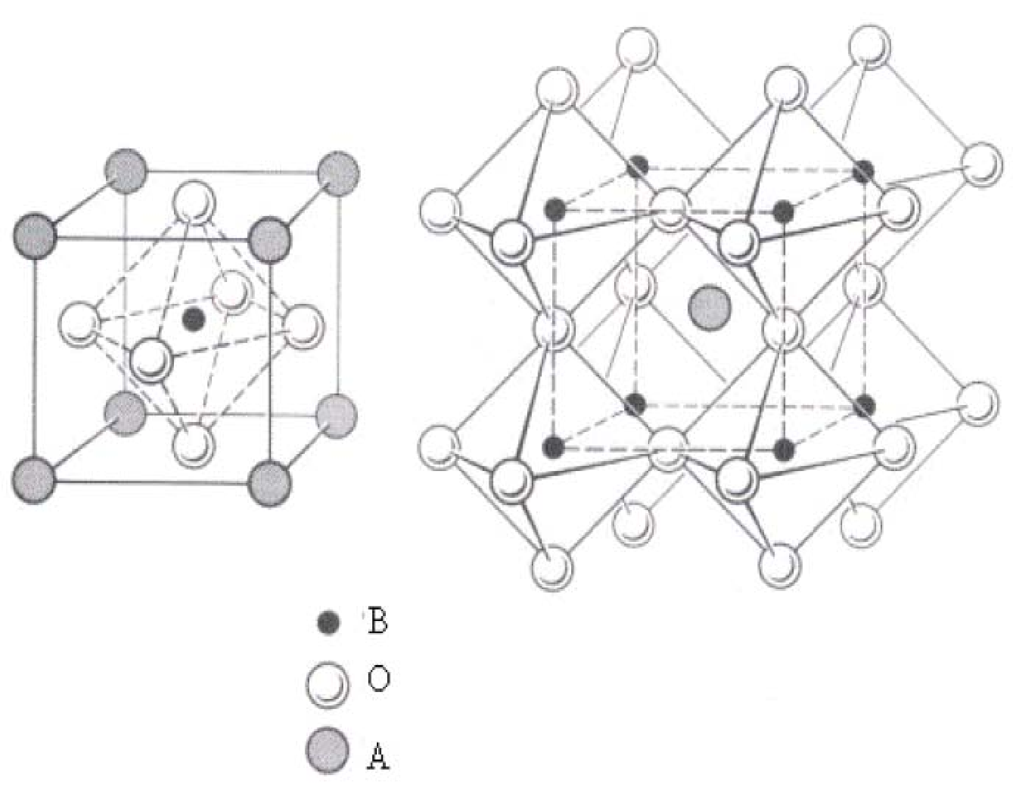
Planar Solid Oxide Fuel Cells



Sulfur Tolerant Anodes

Perovskites for sulfur tolerance

- What is a perovskite?
  - General composition: ABO_3
    - e.g. $LaSrVO_3$
  - Varying amounts of A and B components affect material properties such as electronic conductivity and catalytic activity

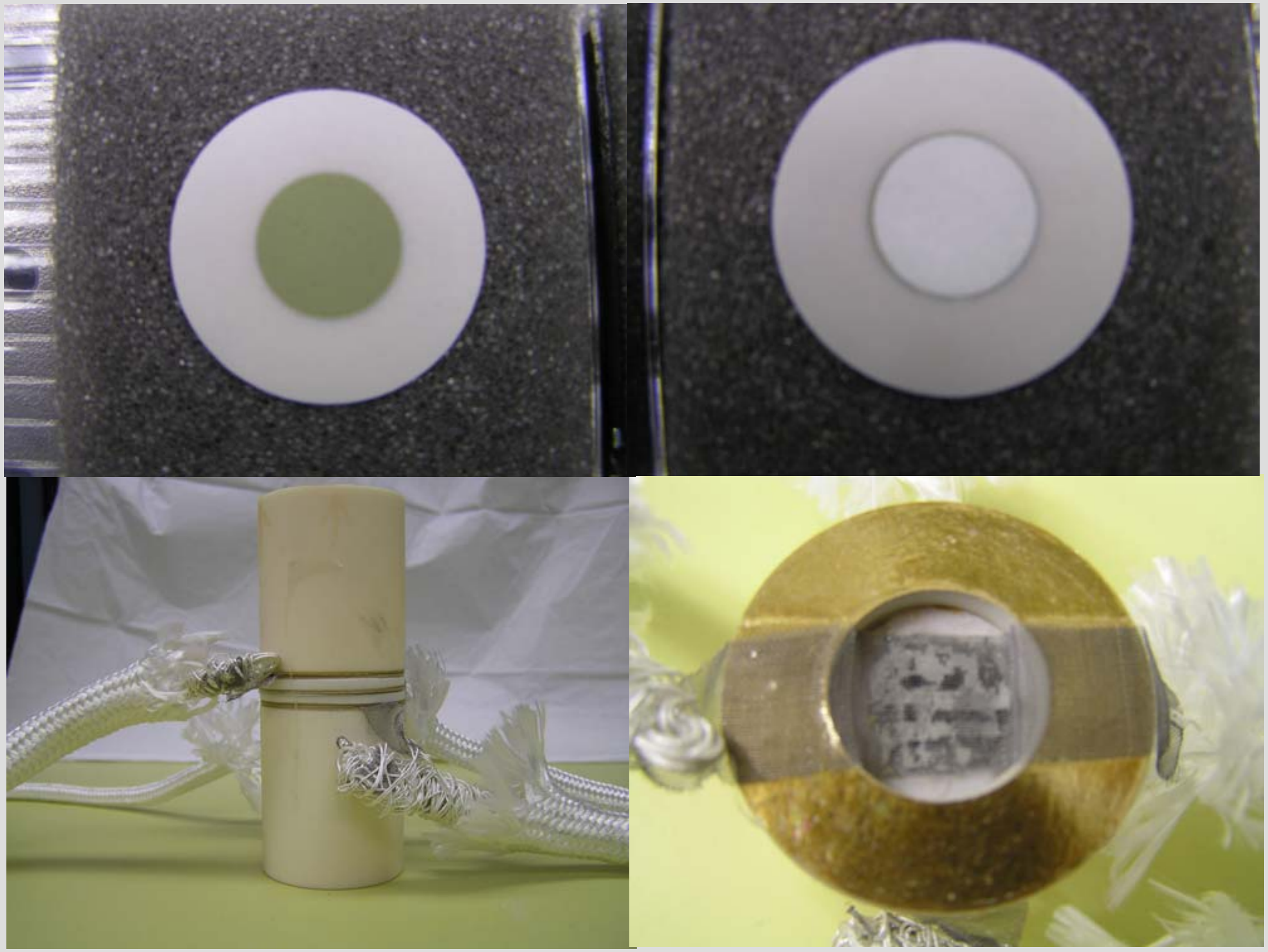


Experimental

Test Stands

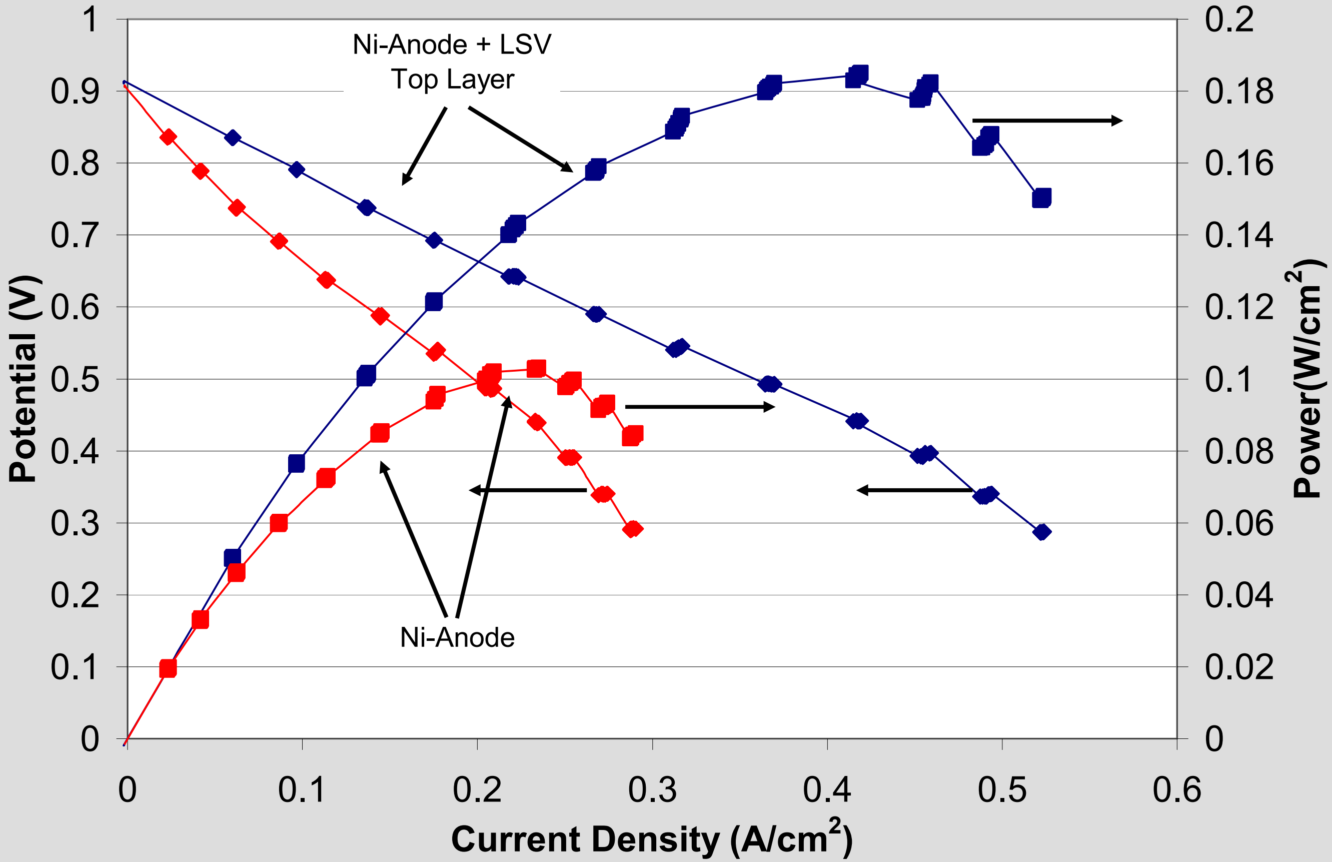
Experimental

Screen Printed Top Layer and Button Cell Setup



Sulfur Tolerant Anode

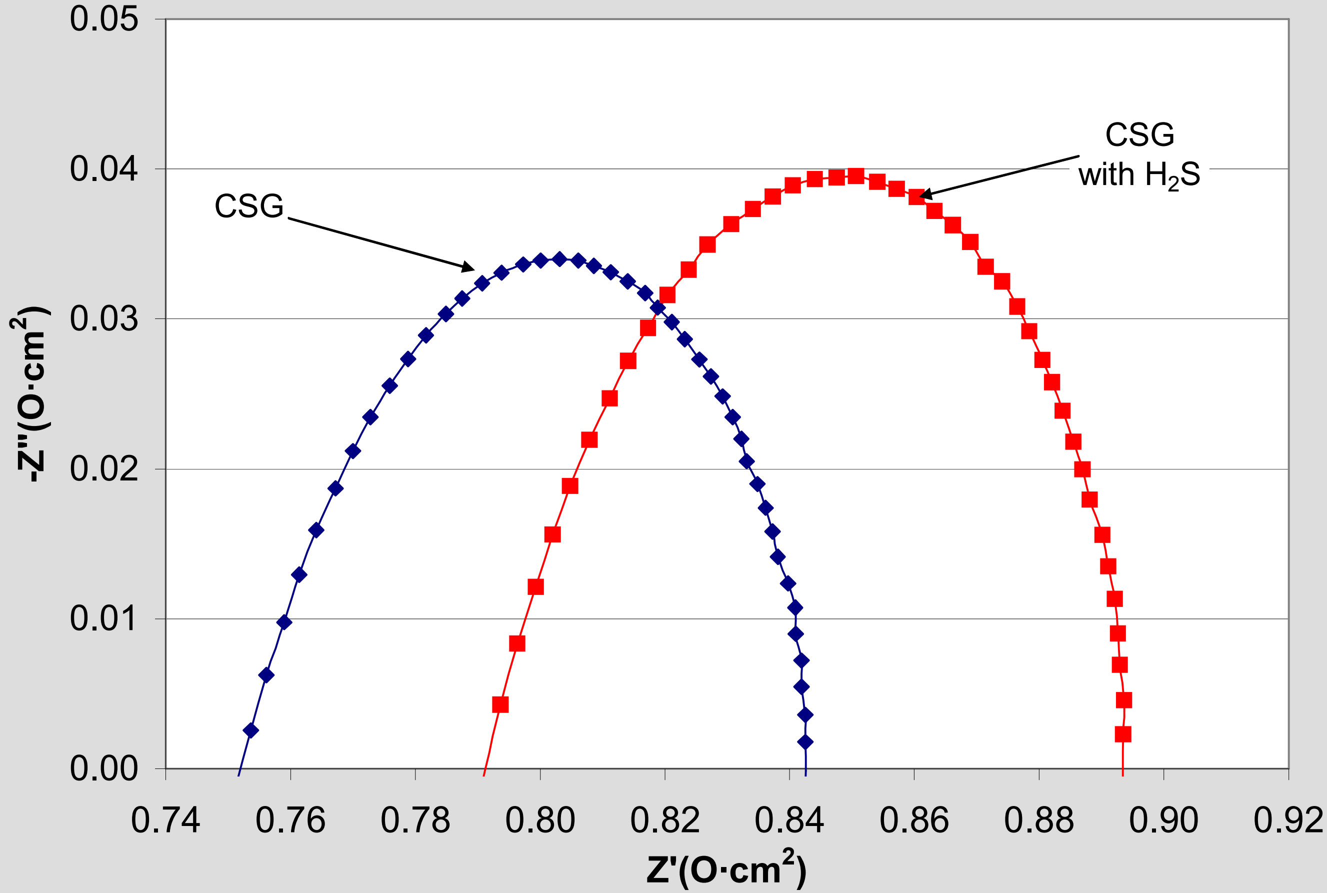
Results



VI Scan Results for Nextcell Anode and Nextcell Anode with Sulfur Tolerant Top Layer Utilizing Coal Syngas with 160ppm H_2S.

Sulfur Tolerant Anode

Results



EIS Results for Nextcell Anode and Nextcell Anode with Sulfur Tolerant Top Layer Utilizing Coal Syngas with 160ppm H_2S.

Model Application

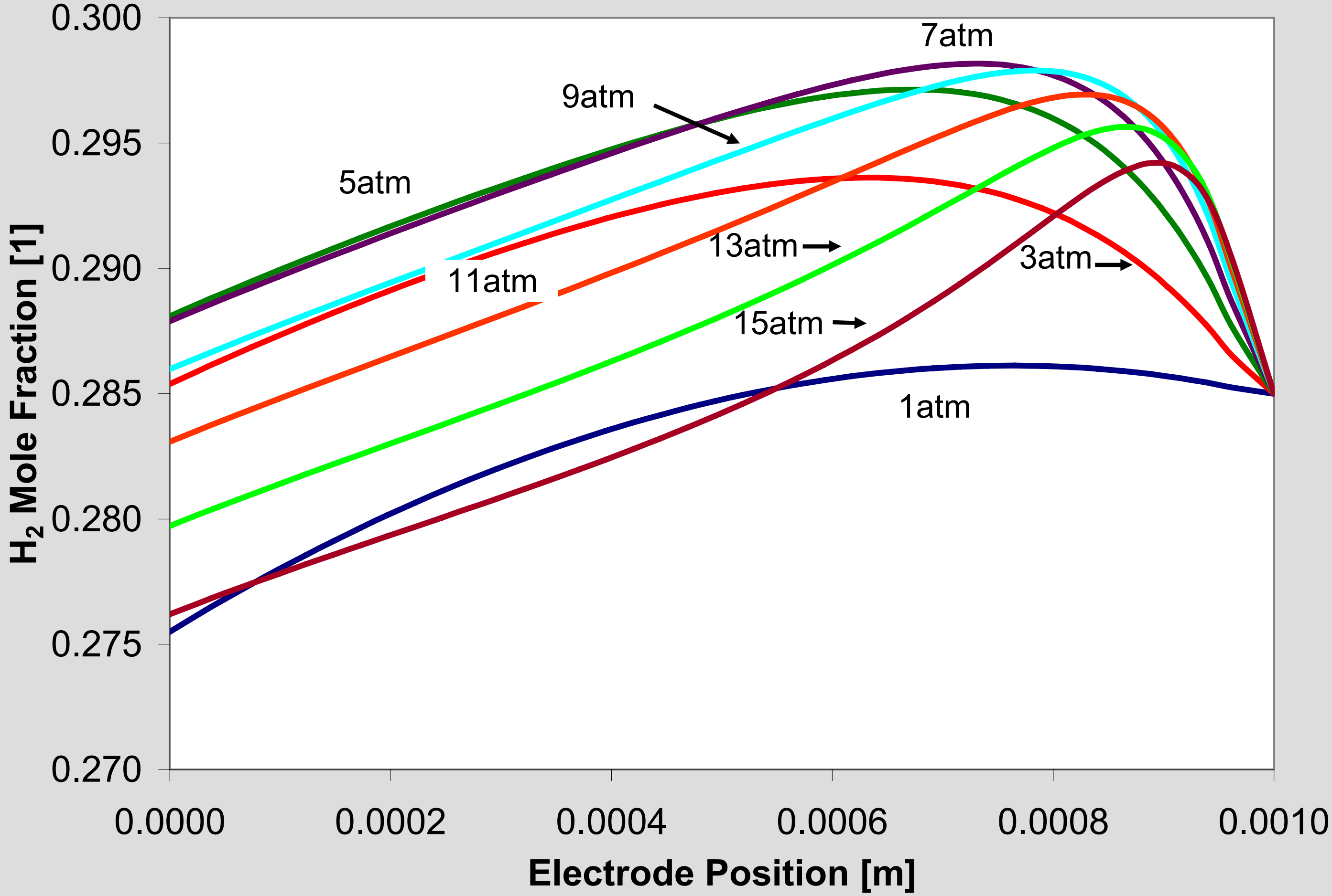
SOFC Anode Characteristics

Anode Electrode Properties [Trembly]

Parameter	Value
Thickness, L	**0.002 m**
Tortuosity, τ	**3.6**
Permittivity, $\Psi=\varepsilon/\tau$	**0.156**
Mean Pore Diameter, $\langle r \rangle$	**1.07 μm**
Operating Temperature, T	**800^{o}C**

Model Application

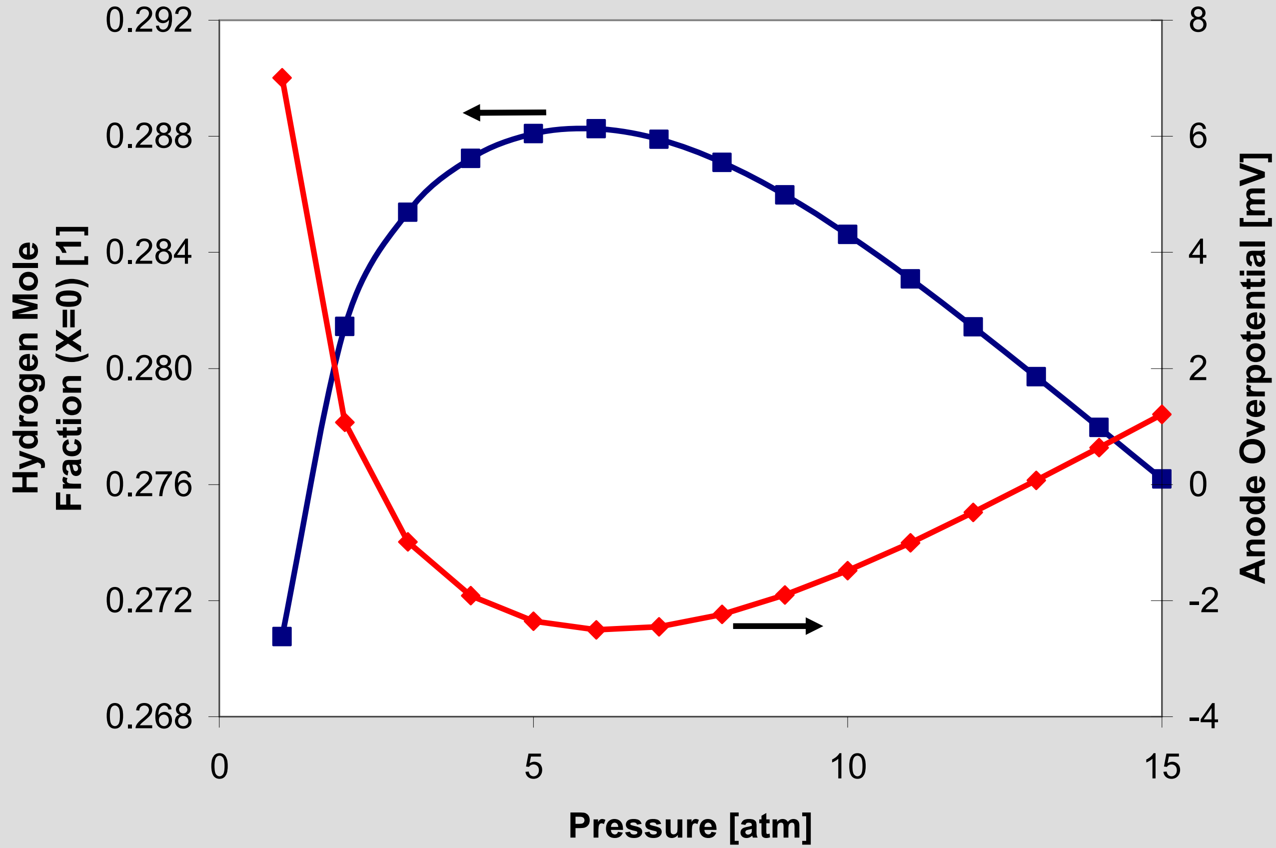
Pressure Effects



Hydrogen profiles through the electrode at 500 mA/cm^2.

Model Application

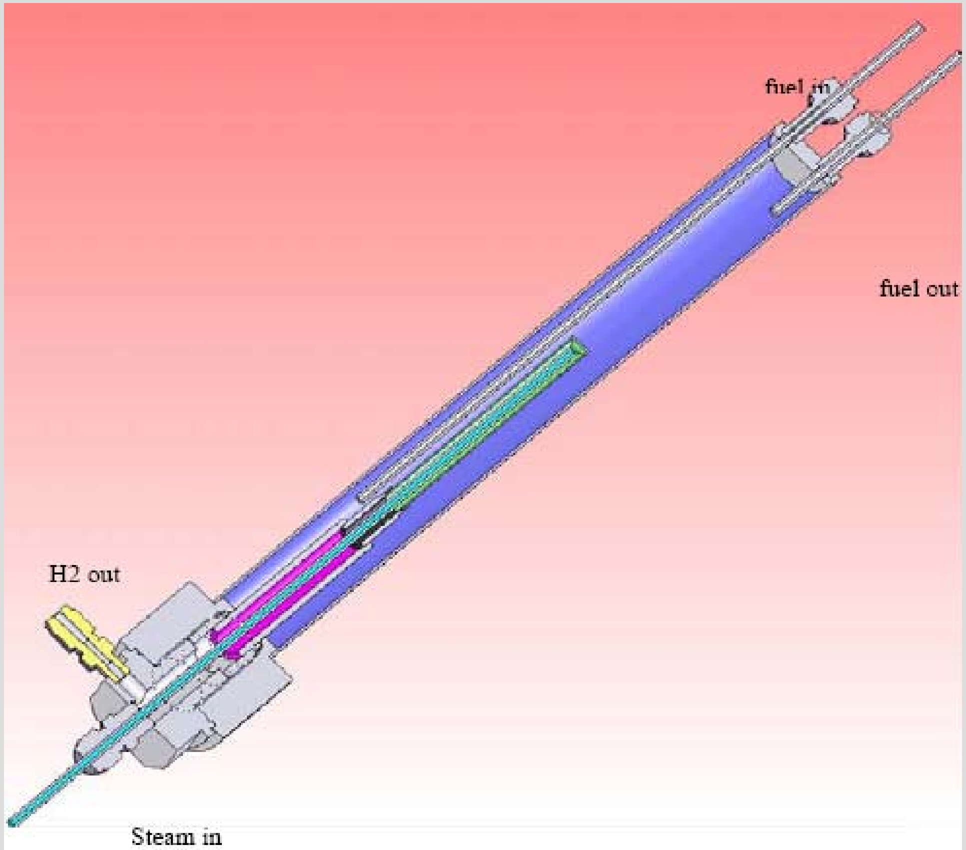
Pressure Effects



H_2 mole fraction at the anode-electrolyte interface, and concentration overpotential loss due to gas phase diffusion (500 mA/cm^2)

Hydrogen Generation

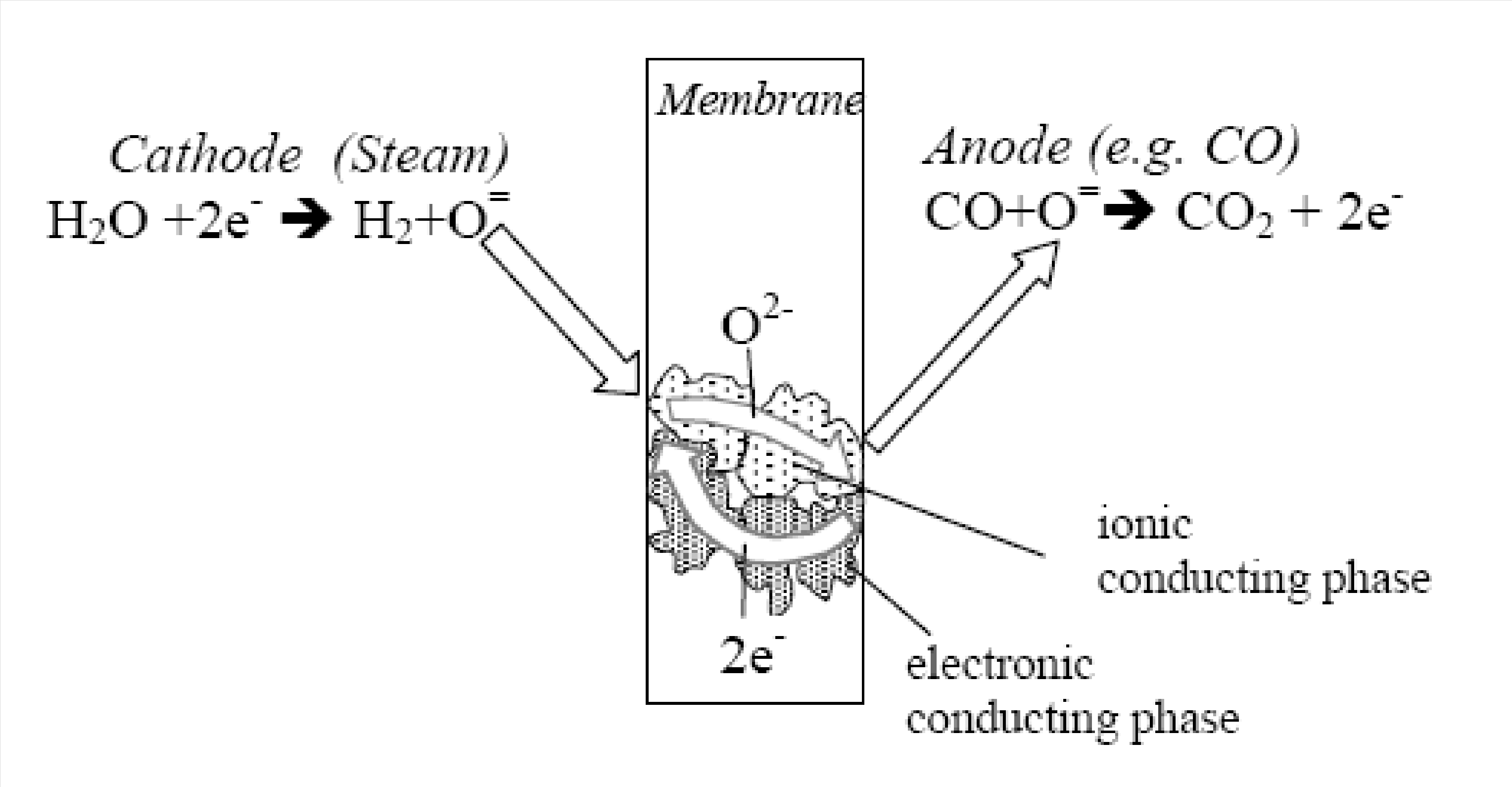
Chemical Electrolysis using MEICs



Schematic of H_2 generation using chemically drive hydrolysis (CTP-Hydrogen)

Hydrogen Generation

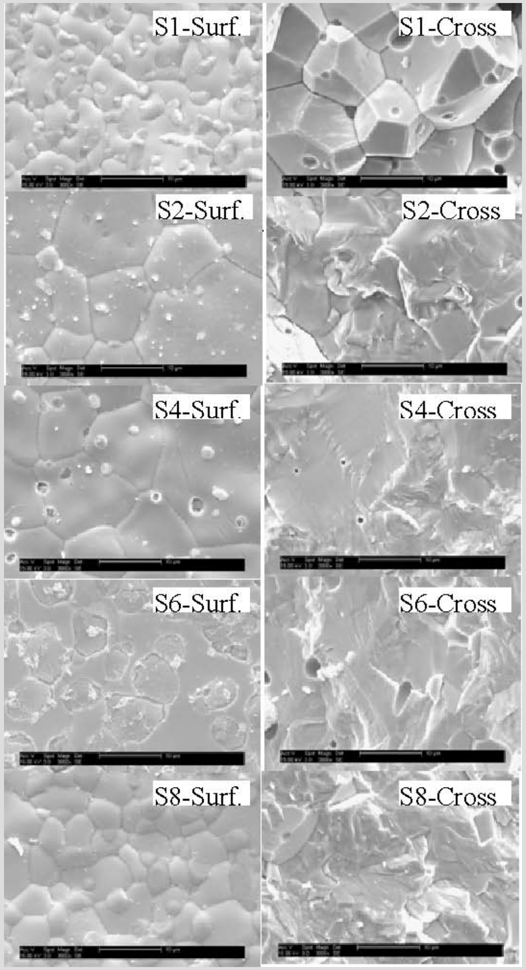
Chemical Electrolysis using MEICs



H_2 generation by chemically driven electrolysis

Ceramic Membranes for H_2 Separation

SCTM Membranes

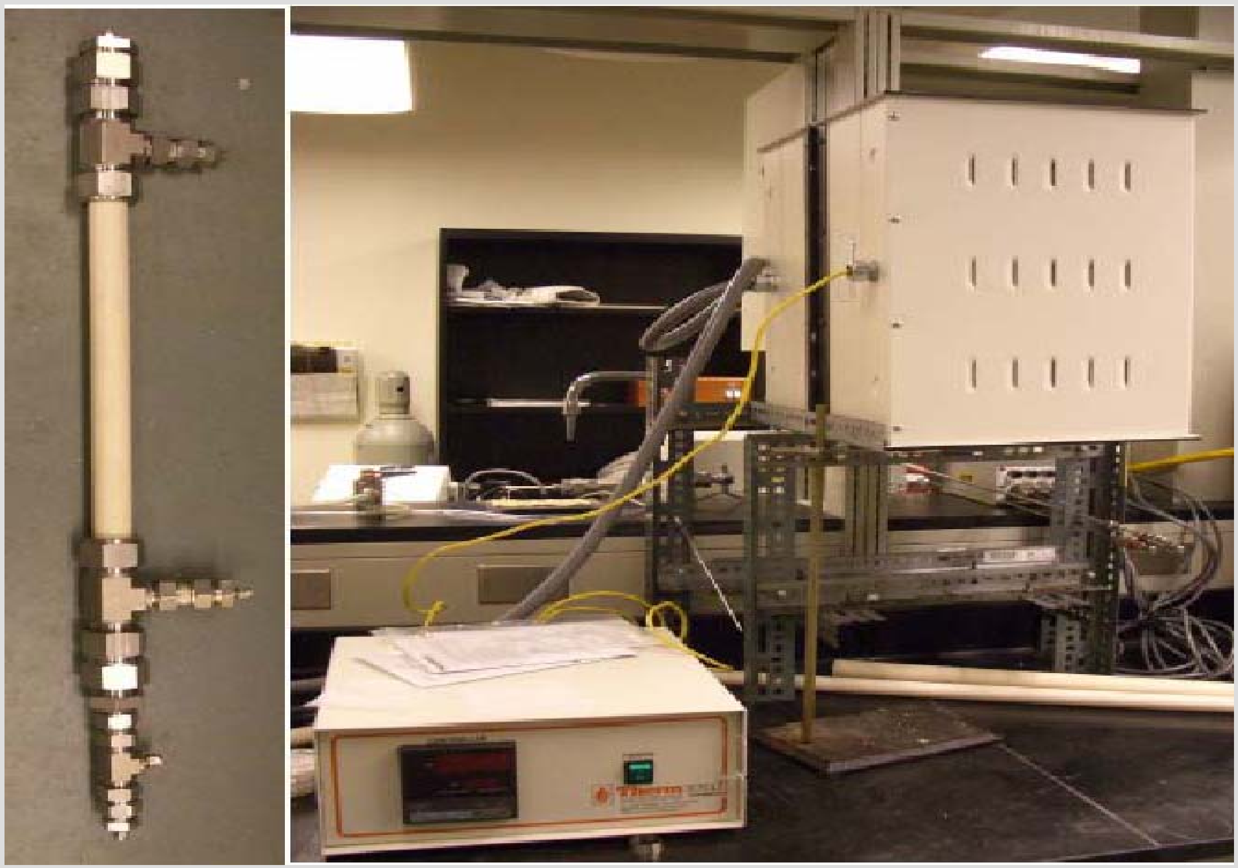


$SrCe_{0.90}Yb_{0.05}Tm_{0.05}O_{3-d}$ (S2), $SrCe_{0.85}Yb_{0.05}Tm_{0.05}Zr_{0.05}O_{3-d}$ (S4), $SrCe_{0.75}Yb_{0.05}Tm_{0.05}Zr_{0.15}O_{3-d}$ (S6), and $SrCe_{0.65}Yb_{0.05}Tm_{0.05}Zr_{0.25}O_{3-d}$ (S8) were prepared by using EDTA-citric acid combined complex method with total metal ions and pH value were kept to 1.6: 1.0: 1.0 and 6.0 respectively. The gel was then heated at 120-150°C for several hours to make primary powders, which was calcined at 900°C for 5 h. The resulted powders were pressed into disks and sintering at 1500°C for 24 hours. SEM images of the disks are shown (Guliants)

Ceramic Membranes for H_2 Separation

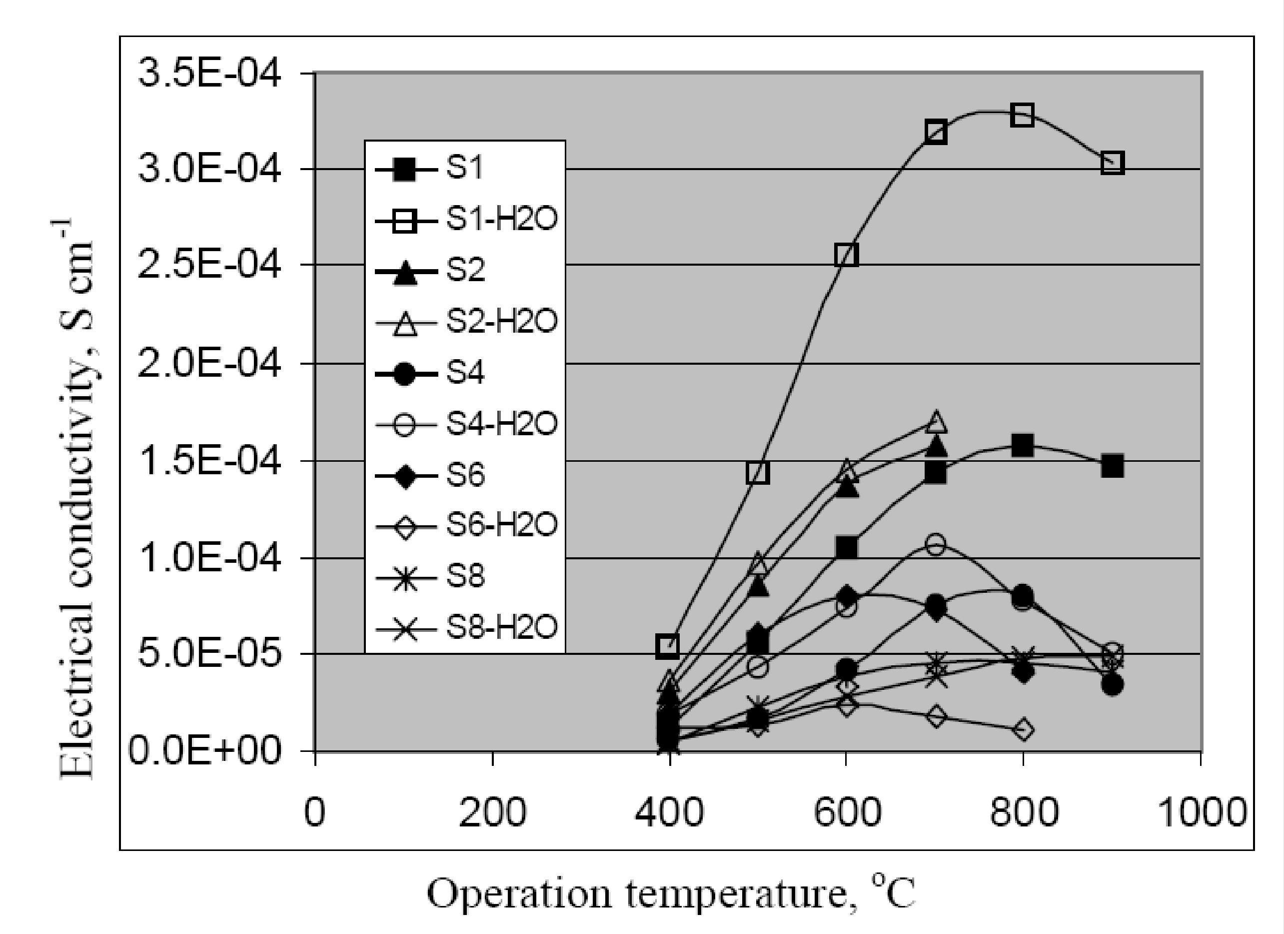
SCTM Membranes

Hydrogen permeation cell



Ceramic Membranes for H_2 Separation

SCTM Membranes



Ceramic Membranes for H_2 Separation

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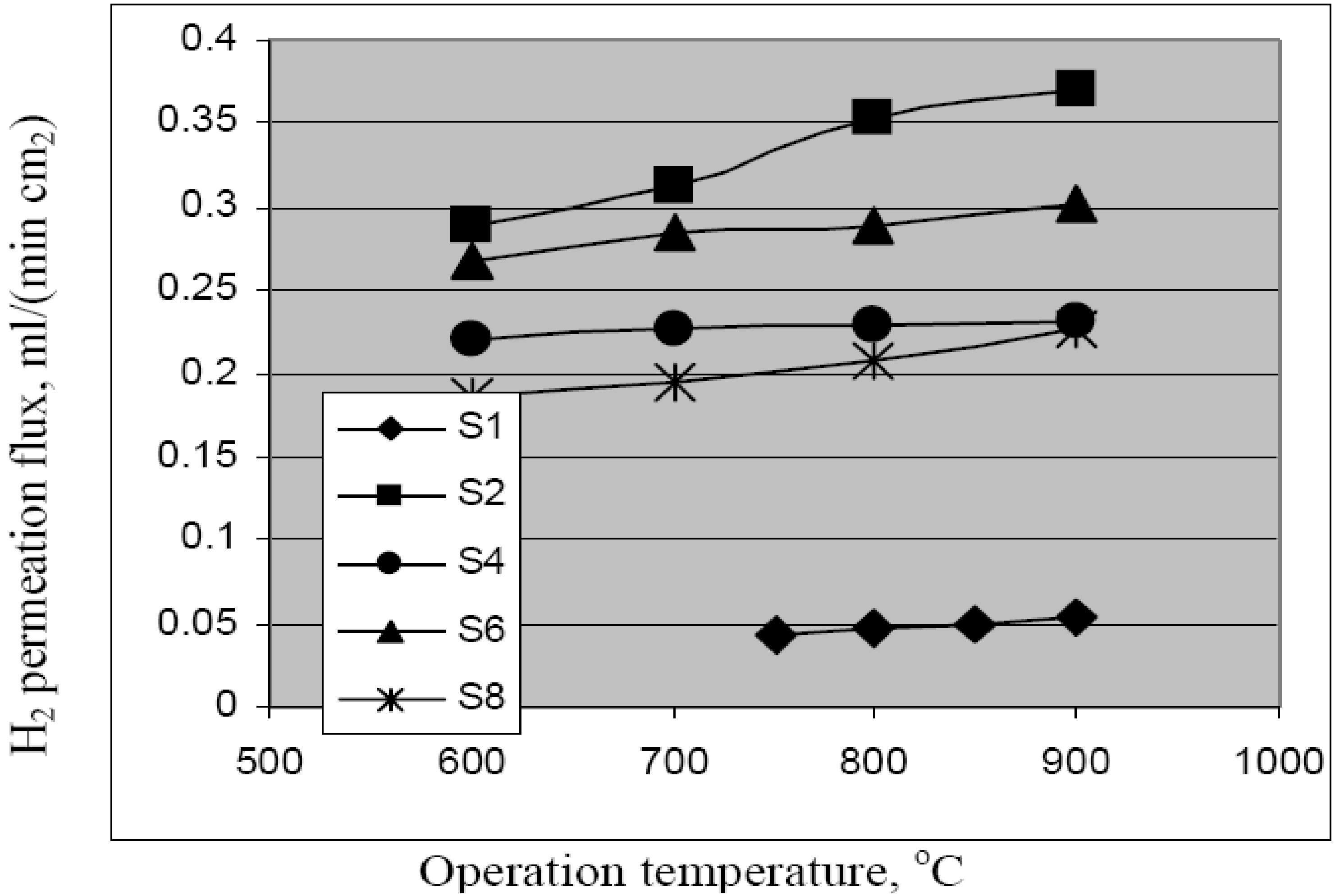
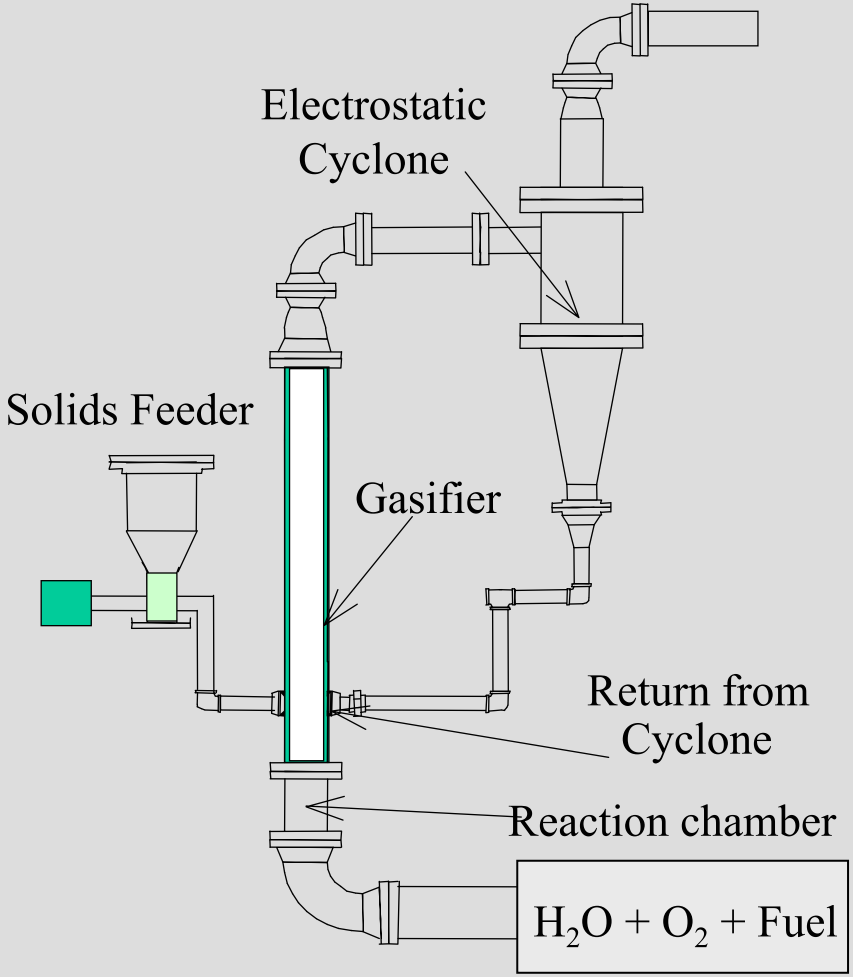


Gasification to Optimize H_2 Production

Indirect Fluidized Bed Gasification



Gasification to Optimize H_2 Production

Indirect Fluidized Bed Gasification

Governing Reactions

$CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$ $\Delta H = -\ 802.0$ kJ/mol

Pyrolysis (devolatilization)

$C + H_2O \rightarrow CO + H_2$ $\Delta H = +\ 119.3$ kJ/mol

$C + CO_2 \rightarrow 2\ CO$ $\Delta H = +\ 170.0$ kJ/mol

$CH_4 + H_2O \rightarrow CO + 3\ H_2$ $\Delta H = +\ 206.1$ kJ/mol

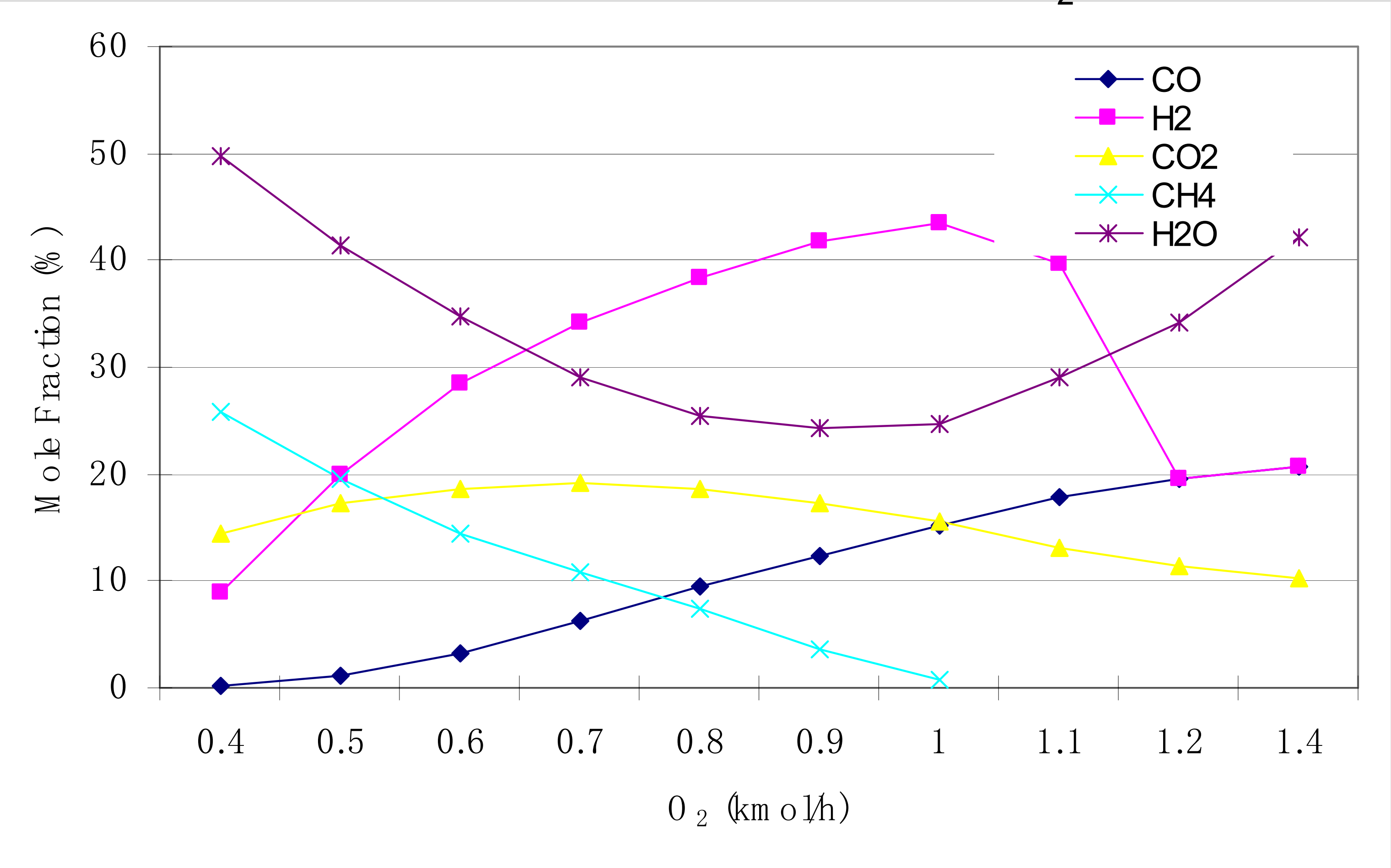
$CH_4 + CO_2 \rightarrow 2\ CO + 2\ H_2$ $\Delta H = +\ 247.3$ kJ/mol

$CO + H_2O \rightarrow H_2 + CO_2$ $\Delta H = -\ 41.15$ kJ/mol

Gasification to Optimize H_2 Production

Indirect Fluidized Bed Gasification

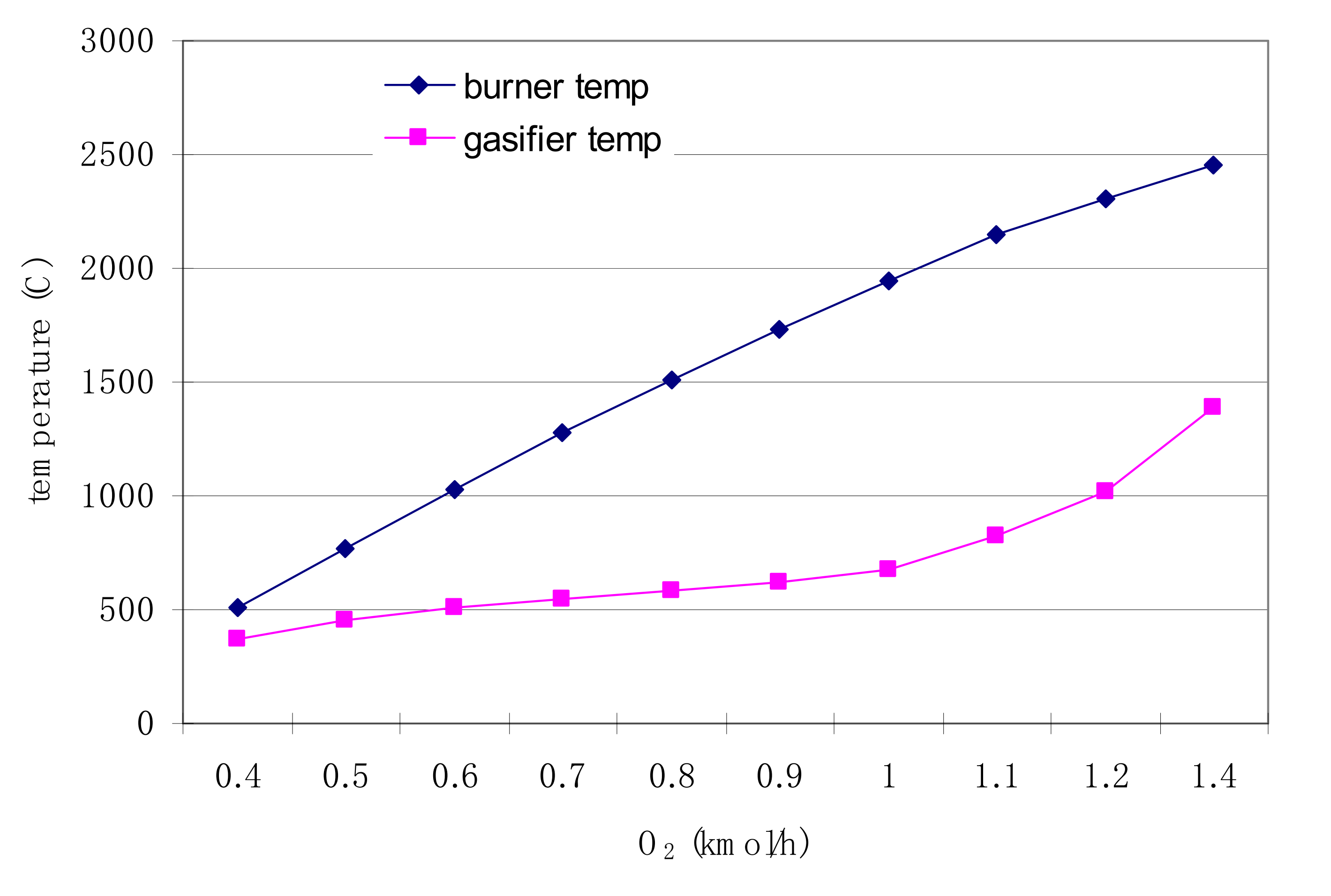
Gas Yields as a function of burner O_2 level



Gasification to Optimize H_2 Production

Indirect Fluidized Bed Gasification

Reactor and Burner Temperature as a function of burner O_2 level



Acknowledgments

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